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(54) **MULTI-BAND ANTENNA AND AN ELECTRONIC DEVICE INCLUDING THE SAME**

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H01Q 1/24 (2006.01)
H01Q 9/42 (2006.01)
H01Q 5/371 (2015.01)
H01Q 5/378 (2015.01)

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CPC ***H01Q 1/50*** (2013.01); ***H01Q 1/243*** (2013.01); ***H01Q 5/371*** (2015.01); ***H01Q 5/378*** (2015.01); ***H01Q 9/42*** (2013.01)

(58) **Field of Classification Search**
USPC .... 343/700 MS, 702, 866, 867
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,125,810	A	11/1978	Pavio	
6,229,487	B1 *	5/2001	Sadler et al.	343/700 MS
6,476,769	B1 *	11/2002	Lehtola	343/702
6,911,940	B2	6/2005	Poilasne et al.	
7,091,908	B2 *	8/2006	Fabrega-Sanchez	343/700 MS
7,362,286	B2 *	4/2008	Fang	343/895
7,551,142	B1	6/2009	Zhang et al.	
8,421,682	B2	4/2013	Nielsen et al.	
8,779,999	B2	7/2014	Gummalla	
2004/0252061	A1	12/2004	Vance	
2008/0106478	A1	5/2008	Hill	

(Continued)

OTHER PUBLICATIONS

Oh, Sung Hoon, et al., U.S. Appl. No. 14/159,880, filed Jan. 21, 2014, entitled "Wideband Antenna and An Electronic Device Including the Same".

Oh, Sung Hoon, et al., U.S. Appl. No. 14/160,036, filed Jan. 21, 2014, entitled "Wideband Loop Antenna and An Electronic Device Including the Same".

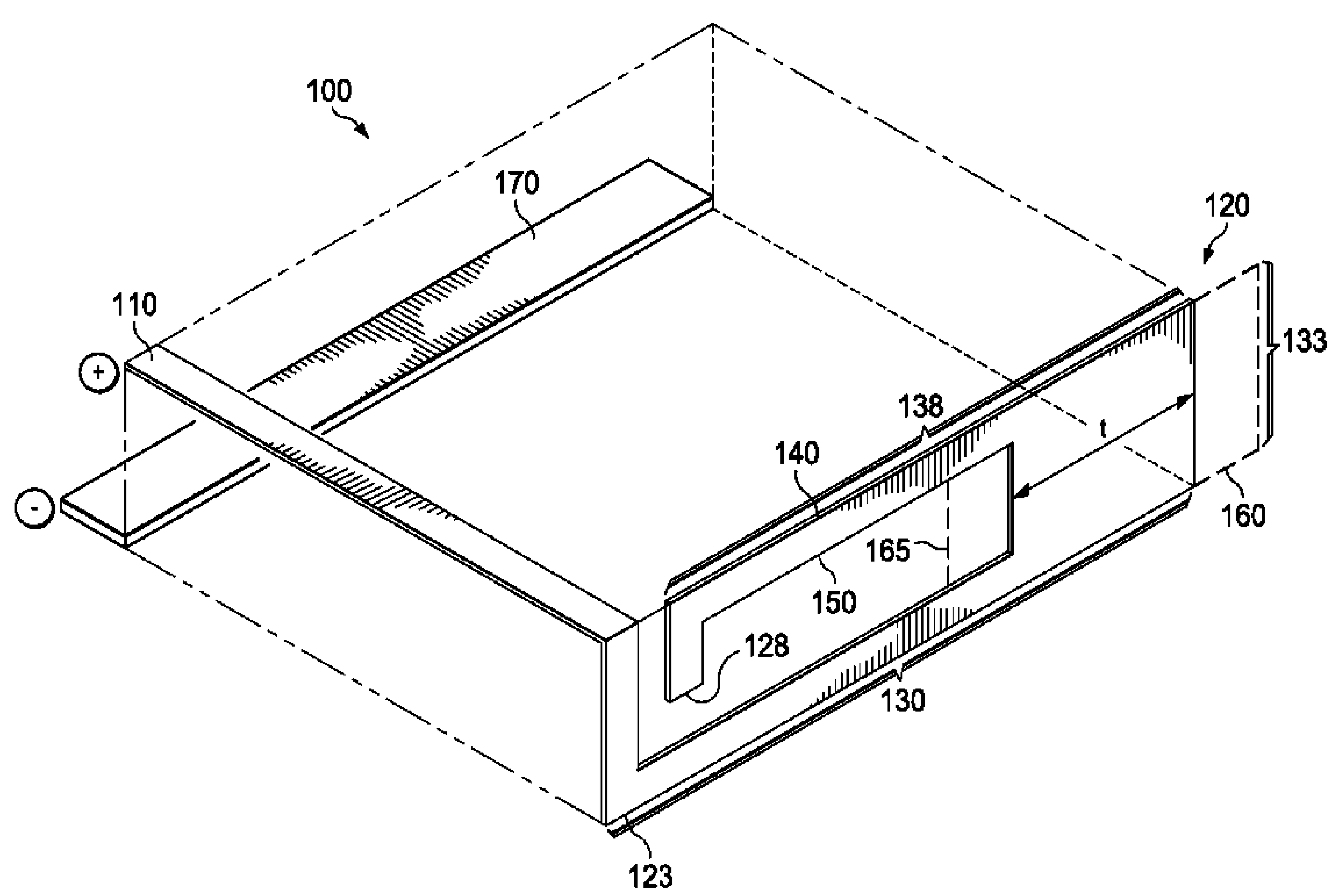
(Continued)

Primary Examiner — Tan Ho

(57) **ABSTRACT**

Provided is a multi-band antenna. The multi-band antenna, as provided in one embodiment, includes a first resonant portion having a first length defined by an outer perimeter of a conductive segment and operable to effect an antenna for communication in a first band of frequencies. The multi-band antenna, in this aspect, further includes a second resonant portion having a second length defined by an inner perimeter of the conductive segment and operable to resonate capacitively for communication in a second different band of frequencies.

20 Claims, 4 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0321255	A1	12/2010	Kough et al.
2012/0154223	A1	6/2012	Oh et al.
2012/0249393	A1	10/2012	Hotta et al.
2013/0050057	A1	2/2013	Hayashi et al.
2014/0118204	A1	5/2014	Gavilan et al.
2015/0022402	A1	1/2015	Gavilan et al.
2015/0022401	A1	2/2015	Gavilan et al.

OTHER PUBLICATIONS

Oh, Sung Hoon, et al., U.S. Appl. No. 14/160,231, filed Jan. 21, 2014, entitled "Co-Located Antennas and An Electronic Device Including the Same".

Oh, Sung Hoon, et al., U.S. Appl. No. 14/160,277, filed Jan. 21, 2014, entitled "Single Element Dual-Feed Antennas and an Electronic Device Including the Same".

* cited by examiner

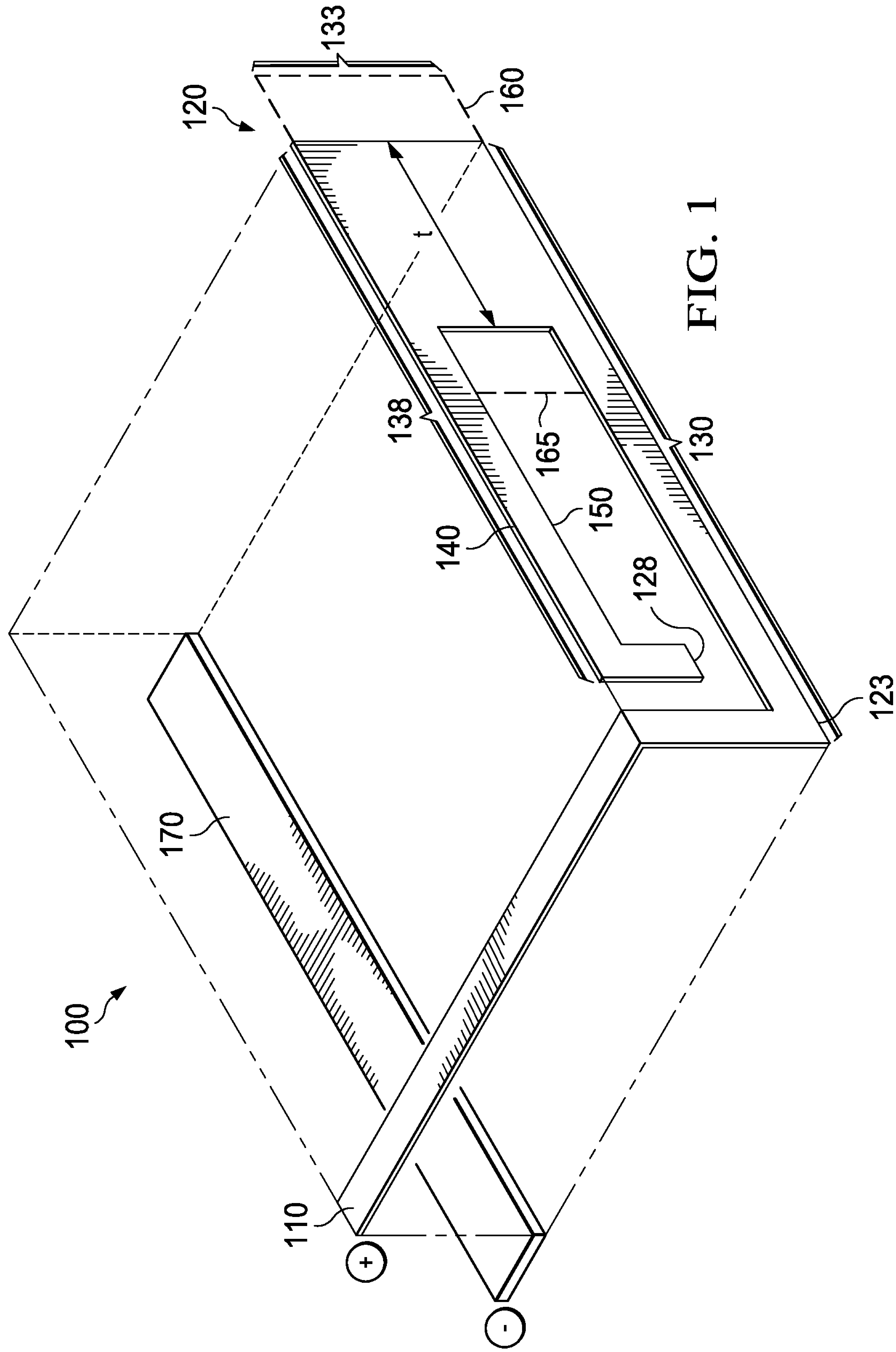


FIG. 1

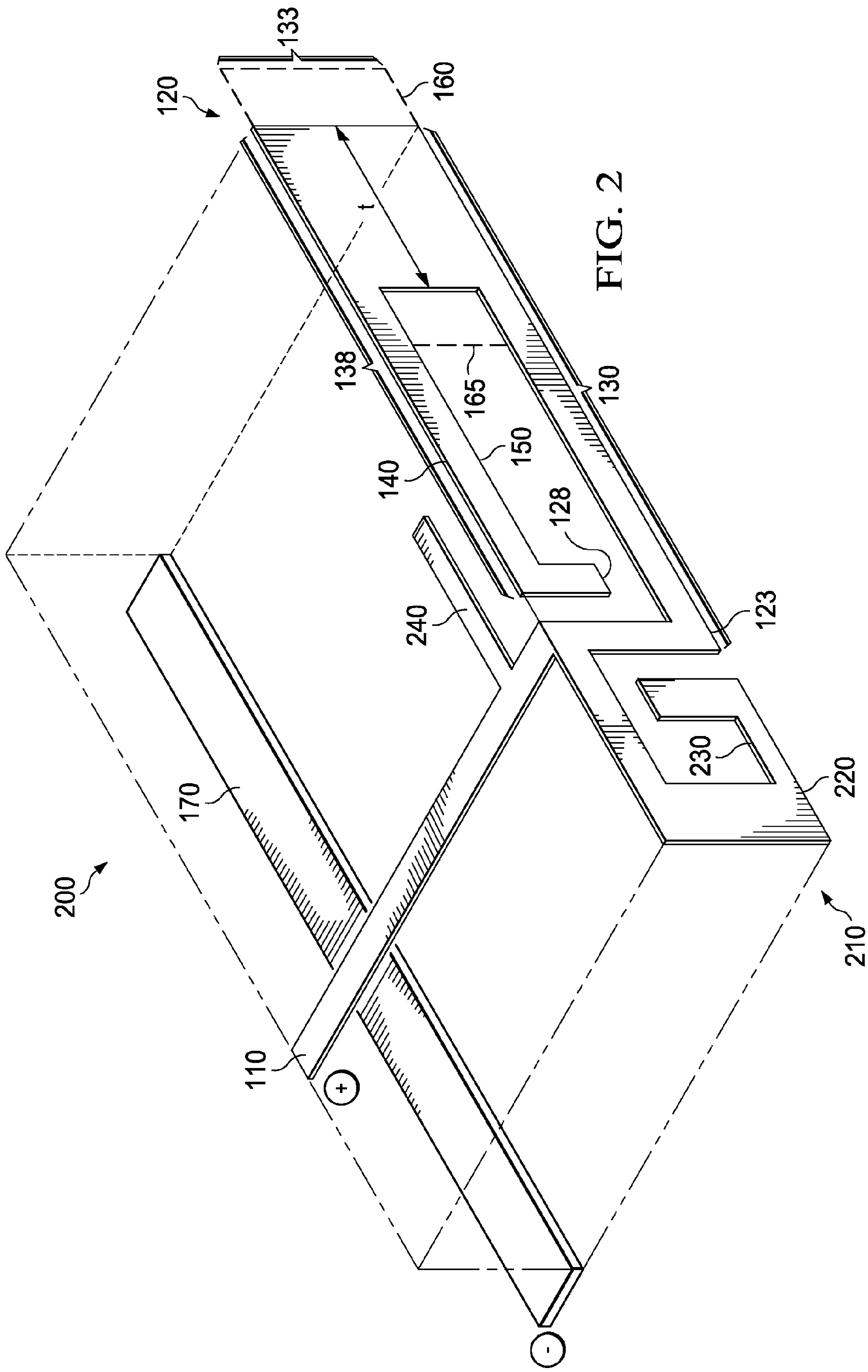

133
120
160
t
138
165
130
150
140
128
240
123
230
220
170
200
210
110
+
-

FIG. 2

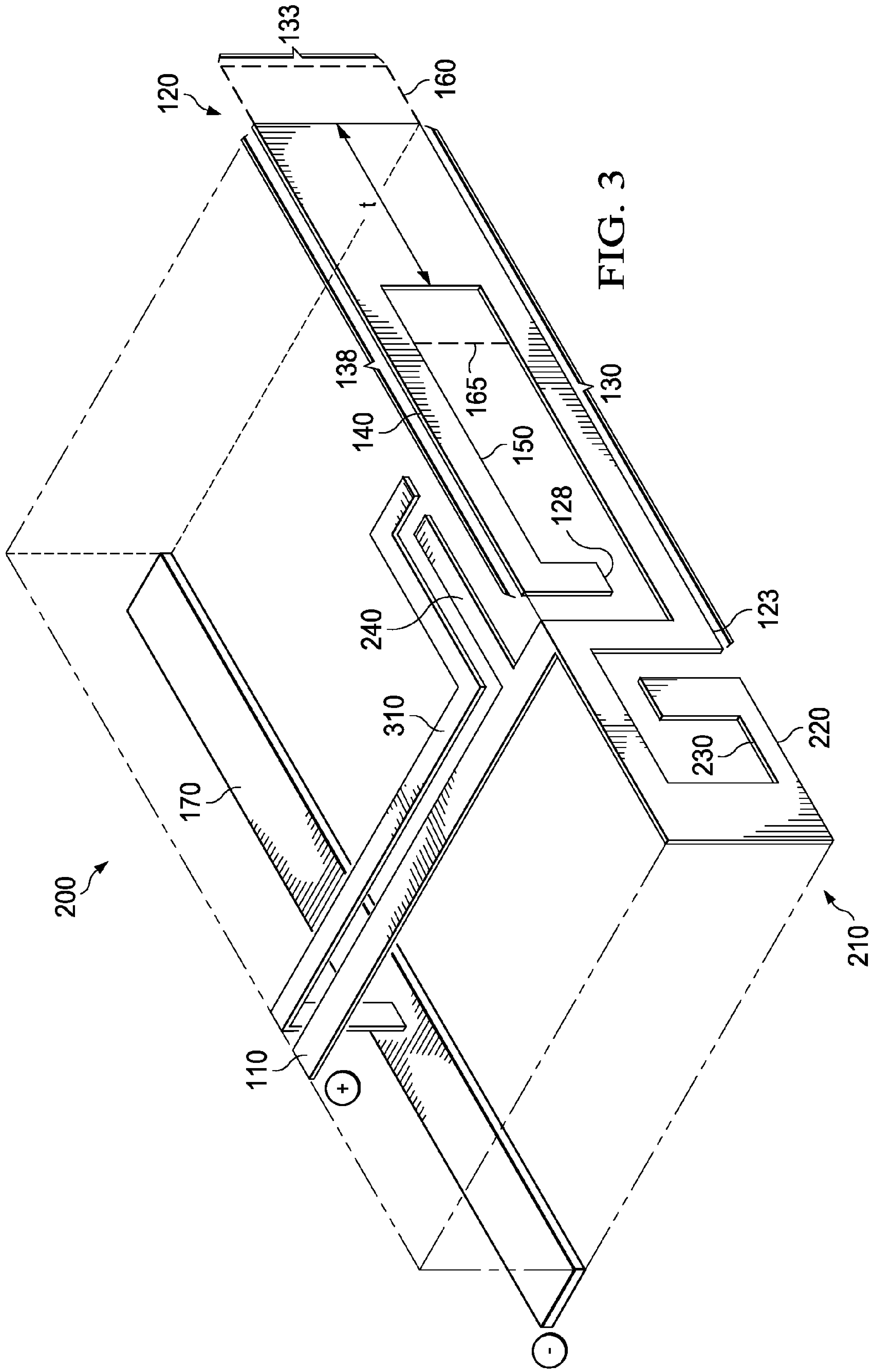

133
120
160
t
138
165
130
140
150
128
123
240
310
220
230
170
200
210
110
+
-

FIG. 3

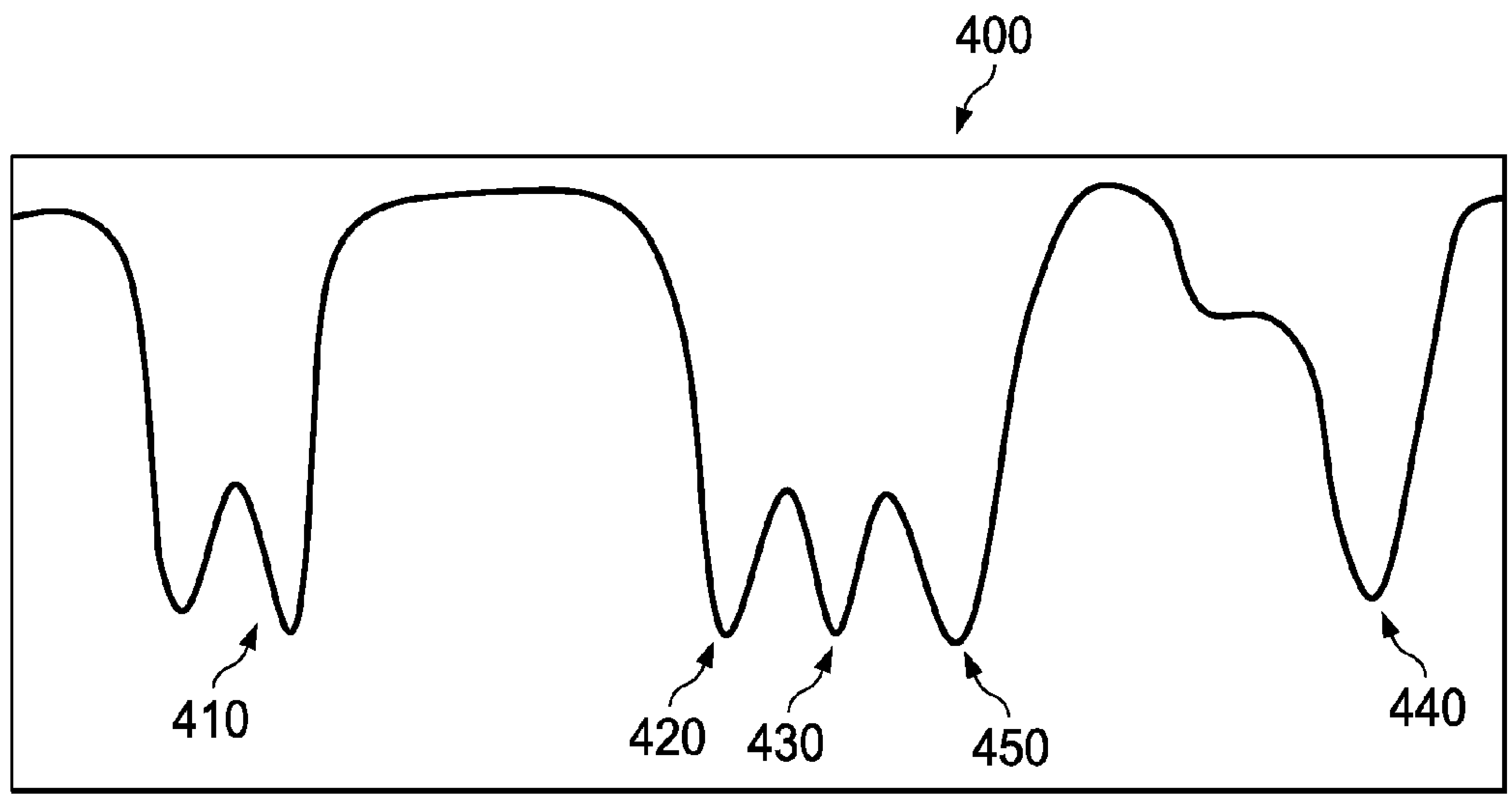

400
410
420
430
450
440

FIG. 4

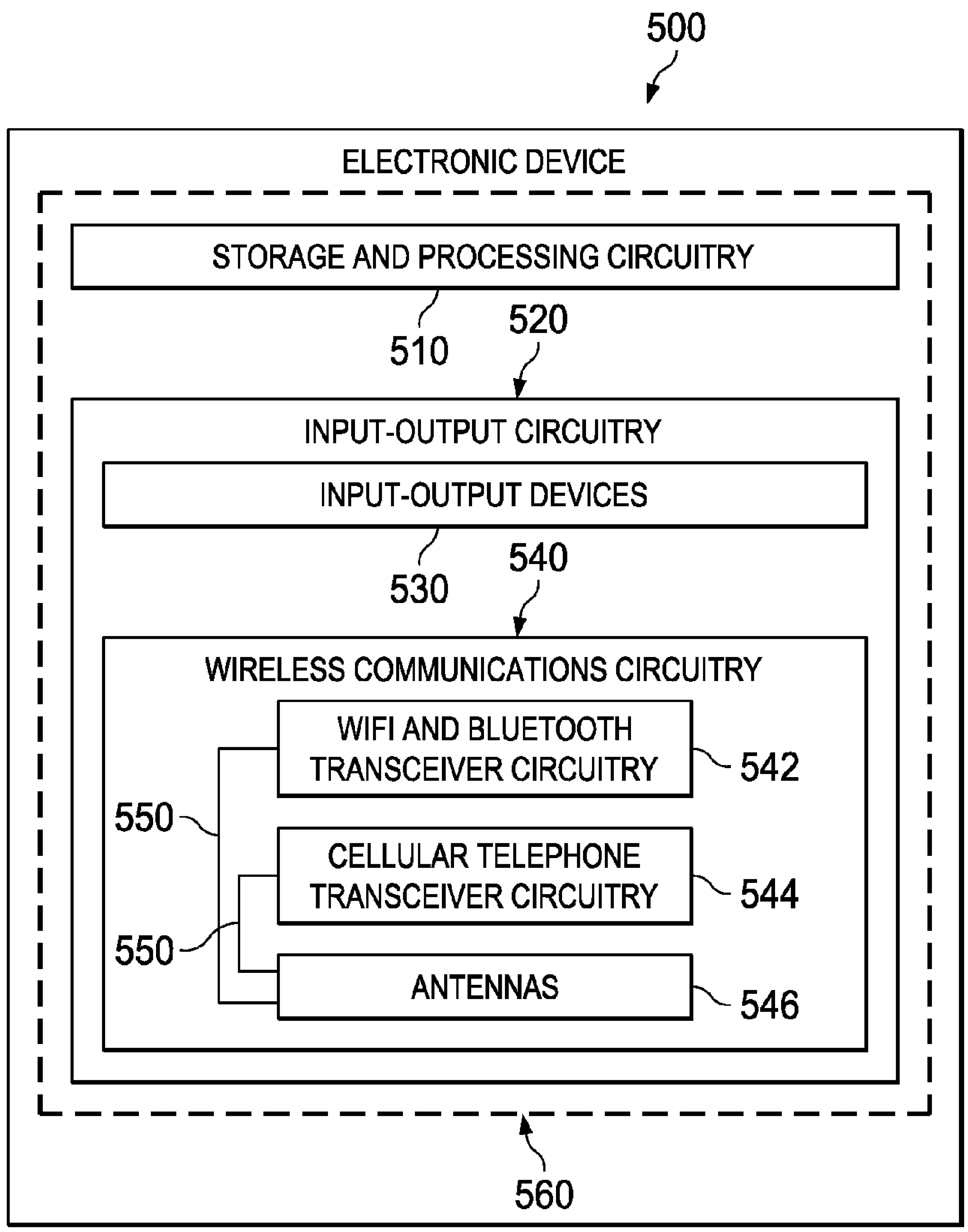

500
ELECTRONIC DEVICE
STORAGE AND PROCESSING CIRCUITRY
510
520
INPUT-OUTPUT CIRCUITRY
INPUT-OUTPUT DEVICES
530
540
WIRELESS COMMUNICATIONS CIRCUITRY
WIFI AND BLUETOOTH TRANSCEIVER CIRCUITRY
542
550
CELLULAR TELEPHONE TRANSCEIVER CIRCUITRY
544
550
ANTENNAS
546
560

FIG. 5

MULTI-BAND ANTENNA AND AN ELECTRONIC DEVICE INCLUDING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Application Ser. No. 61/721,358, filed by Joselito Gavilan, et al., on Nov. 1, 2012, entitled "Antennas Integrated with Metal Housings," commonly assigned with this application and incorporated herein by reference.

TECHNICAL FIELD

This application is directed, in general, to antennas and, more specifically, to multi-band antennas for handheld electronic devices.

BACKGROUND

Handheld electronic devices are becoming increasingly popular. Examples of handheld devices include handheld computers, cellular telephones, media players, and hybrid devices that include the functionality of multiple devices of this type.

Due in part to their mobile nature, handheld electronic devices are often provided with wireless communications capabilities. Handheld electronic devices may use long-range wireless communications to communicate with wireless base stations. For example, cellular telephones may communicate using 2G Global System for Mobile Communication (commonly referred to as GSM) frequency bands at about 850 MHz, 900 MHz, 1800 MHz, and 1900 MHz, among possible others. Communication is also possible in the 3G Universal Mobile Telecommunication System (commonly referred to as UMTS) and 4G Long Term Evolution (commonly referred to as LTE) frequency bands which range from 700 MHz to 3800 MHz. Furthermore, communication can operate on channels with variable bandwidths of 1.4 MHz to 20 MHz for LTE, as opposed to the fixed bandwidths of GSM (0.2 MHz) and UMTS (5 MHz). Handheld electronic devices may also use short-range wireless communications links. For example, handheld electronic devices may communicate using the Wi-Fi® (IEEE 802.11) bands at about 2.4 GHz and 5 GHz, and the Bluetooth® band at about 2.4 GHz. Handheld devices with Global Positioning System (GPS) capabilities receive GPS signals at about 1575 MHz.

To satisfy consumer demand for small form factor wireless devices, manufacturers are continually striving to reduce the size of components that are used in these devices. For example, manufacturers have made attempts to miniaturize the antennas used in handheld electronic devices. Unfortunately, doing so within the confines of the wireless device package is challenging.

Accordingly, what is needed in the art is an antenna, and associated wireless handheld electronic device that navigates the desires and problems associated with the foregoing.

SUMMARY

One aspect provides a multi-band antenna. The multi-band antenna, in this aspect, includes a first resonant portion having a first length defined by an outer perimeter of a conductive segment and operable to effect an antenna for communication in a first band of frequencies. The multi-band antenna, in this aspect, further includes a second resonant portion having a second length defined by an inner perimeter of the conductive segment and operable to resonate capacitively for communication in a second different band of frequencies.

Another aspect provides an electronic device. The electronic device, in this aspect, includes storage and processing circuitry, input-output devices associated with the storage and processing circuitry, and wireless communications circuitry including a multi-band antenna. The multi-band antenna, in this aspect, includes: 1) a first resonant portion having a first length defined by an outer perimeter of a conductive segment and operable to effect an antenna for communication in a first band of frequencies, and 2) a second resonant portion having a second length defined by an inner perimeter of the conductive segment and operable to resonate capacitively for communication in a second different band of frequencies.

BRIEF DESCRIPTION

Reference is now made to the following descriptions taken in conjunction with the accompanying drawings, in which:

FIG. **1** illustrates aspects of a representative embodiment of a multi-band antenna in accordance with embodiments of the disclosure;

FIG. **2** illustrates alternative aspects of a representative embodiment of a multi-band antenna in accordance with embodiments of the disclosure;

FIG. **3** illustrates alternative aspects of a representative embodiment of a multi-band antenna in accordance with embodiments of the disclosure;

FIG. **4** illustrates an S-parameter plot for a multi-band antenna in accordance with the present disclosure; and

FIG. **5** illustrates aspects of a representative embodiment of electronic device in accordance with embodiments of the disclosure.

DETAILED DESCRIPTION

The present disclosure is based, at least in part, on the recognition that wireless networks are constantly evolving to increase speed and improve data communication, and that the latest cellular network, called Long Term Evolution (LTE) or 4G, not only operates in different frequency bands amongst carriers, but also between different regions. As a result, mobile electronic devices, such as smart phones, tablets and laptops, will need to support multiple LTE bands in addition to the legacy 3G (UMTS) and 2G (GSM) bands. The addition of these frequency bands creates a significant challenge for antenna designers, since the antennas will now need to cover additional bands in the same allocated volume.

With this recognition in mind, the present disclosure acknowledged, for the first time, that to reduce the volume of the antenna, multiple resonant frequencies may be created from a single segment by innovatively designing the geometry of the segment to induce multiple resonant modes. For example, by routing the segment in a shape of a partial loop and keeping the ends close but not touching, the segment may be designed to generate two resonant modes: (1) a resonant mode with frequency depending upon a length of the outer perimeter of the segment and (2) a resonant mode with frequency depending upon a length of the inner perimeter of the segment. Doing such, the present disclosure is capable of creating multiple resonances in the same antenna volume that currently exists today.

The present disclosure has further acknowledged that the two resonant modes will generate responses at two frequencies, which can be used to cover the required bands. Moreover, the present disclosure acknowledged that the frequency and bandwidth of these resonances can be tuned independently of one another, for example through various modifications to the geometry.

The present disclosure has yet further acknowledged that multiple segments, each including two resonant modes, can be coupled together to provide four or more resonant modes in the same antenna volume that currently exists today. Again, each of the four resonant modes, even though they are formed from only two segments, may be adjusted independently of the others.

The present disclosure has additionally acknowledged that a separate conductive segment can be positioned proximate the conductive segment having the two resonant modes, such that a capacitive coupling between the separate conductive segment and the conductive segment provides an effective length of the conductive segment greater than an actual length of the conductive segment. Thus, again within the same antenna volume that currently exists today, the actual length of the segment can be shorter while still achieving the desirable lower frequency bands. This technique can reduce the overall volume of the antenna.

By combining the innovative techniques of this disclosure, the industry would be able to cover multiple frequency bands while maintaining the same antenna volume, which is vital to creating smaller and/or thinner devices. Moreover, such a design would enable a single antenna design to support almost all of the GSM/UMTS/LTE bands, as defined by the 3^{rd} Generation Partnership Project (3GPP).

FIG. **1** illustrates aspects of a representative embodiment of a multi-band antenna **100** in accordance with embodiments of the disclosure. The multi-band antenna **100** of FIG. **1** includes a feed portion **110**. The feed portion **110**, in this embodiment, may be that portion of the multi-band antenna **100** that first receives radio frequency signals from one or more associated transceivers in a related electronic device. For example, the feed portion **110** might directly couple to a positive terminal of a transmission line (not shown), such as a coaxial cable, microstrip, etc., to receive radio frequency signals from associated transceivers, and provide them to the other portions of the multi-band antenna **100**. The feed portion **110** may additionally receive radio frequency signals from the other portions of the multi-band antenna **100**, and thus provide them to the associated transceivers.

Coupled to the feed portion **110** in the embodiment of FIG. **1** is a conductive segment **120**. The term "conductive segment", as used herein, requires that the two ends of the conductor not close back upon themselves to form a closed loop. A closed loop, as well as a slot in a conductor, are not considered conductive segments as that term is defined herein. The conductive segment **120**, in the illustrated embodiment, includes a first end **123** and a second end **128**, and is formed as a partial loop. Further to the illustrative embodiment of FIG. **1**, the conductive segment **120** folds back upon itself to form the partial loop. For instance, in the embodiment shown, the conductive element includes a first section **130**, a second section **133** coupled to the first section **130**, and a third section **138** coupled to the second section **133**. In this embodiment, the second section **133** is shorter than, and substantially perpendicular to, the first section **130**. Additionally, the third section **138** doubles back upon, and is substantially parallel to, the first section **130**. This is but one embodiment of a configuration for the conductive segment **120**. In another embodiment, the conductive segment **120** might take a more circular shape.

The multi-band antenna **100** illustrated in FIG. **1**, as a result of the unique design thereof, includes a first resonant portion **140** and a second resonant portion **150**. The term "resonant portion", as used herein, is intended to mean a portion of the antenna geometry that resonates at a desired band of frequencies. The first resonant portion **140**, in the illustrative embodiment, includes a first length defined by an outer perimeter of the conductive segment **120**. The first length, in the embodiment of FIG. **1**, is defined by an outer perimeter of the first section **130**, second section **133** and third section **138**. The first resonant portion **140**, in accordance with the disclosure, is operable to effect an antenna for communication in first band of frequencies.

The second resonant portion **150**, in the illustrative embodiment, includes a second different length defined by an inner perimeter of the conductive segment **120**. The second different length, in the embodiment of FIG. **1**, is defined by an inner perimeter of the first section **130**, second section **133** and third section **138**. The second resonant portion **150**, as a result of the geometry of the inner loop, includes a capacitive resonance. The term "capacitive resonance", as used herein, is intended to mean the resonance at a desired band of frequencies due to two conductors being capacitively coupled to one another. Accordingly, the second resonant portion **150** is operable to resonate capacitively for communication in a second different band of frequencies.

Unique to the present disclosure, the band of frequencies that the first and second resonant portions **140**, **150** may operate are independently adjustable. For example, the first length and second different length may be modified independent of one another. In the illustrate embodiment, this may be achieved by changing a thickness (t) of at least a portion of the conductive segment **120**. For example, if the thickness (t) of the conductive segment is increased, for example to the dotted line **160**, the first length would be increased without changing the second different length. Alternatively, if the thickness (t) of the conductive segment is increased, for example to the dotted line **165**, the second different length would be decreased without changing the first length. Modifications to the thickness (t) of the first and third sections **130**, **138**, like the second section **133**, may also modify the first and second lengths independent of one another. Therefore, modifications in the geometry of the conductive segment **120** can be used to independently tune the first and second resonant portions **140**, **150**.

The first and second resonant portions **140**, **150**, in the illustrated embodiment, are substantially planar portions. Accordingly, in the embodiment, of FIG. **1**, the first and second resonant portions **140**, **150** are formed in a same plane. In one embodiment the plane that the first and second resonant portions **140**, **150** are located is coplanar with a plane defined by an edge of the electronic device the multi-band antenna **100** might be employed. In an alternative embodiment, the plane that the first and second resonant portions **140**, **150** are located are coplanar with a plane defined by a display of the electronic device the multi-band antenna **100** might be employed. Other embodiments may exist wherein the first and second portions **140**, **150** are not formed in a same plane.

The multi-band antenna **100** illustrated in the embodiment of FIG. **1** additionally includes a ground (e.g., ground plane) portion **170**. In the illustrated embodiment, ground portion **170** might directly couple to a negative terminal of the transmission line (not shown), such as a coaxial cable, microstrip, etc.

FIG. **2** illustrates alternative aspects of a representative embodiment of a multi-band antenna **200** in accordance with embodiments of the disclosure. Where used, like reference numerals indicate similar features. In addition to the features of FIG. **1**, the multi-band antenna **200** includes a second conductive segment **210** coupled to the feed portion **110**. In this embodiment, the second conductive segment **210** includes a third resonant portion **220** having a third length defined by an outer perimeter of the second conductive segment **210**, and a fourth resonant portion **230** having a fourth length defined by an inner perimeter of the second conductive segment **210**. While the second conductive segment **210** (and first conductive segment **120** for that matter) is illustrated as a counter-clockwise partial loop, those skilled in the art understand that it could just as easily been configured as a clockwise partial loop and remain within the scope of the present disclosure. Accordingly, the third resonant portion **220** is operable to effect an antenna for communication in a third band of frequencies, and the fourth resonant portion **230** is operable to resonate capacitively for communication in a fourth different band of frequencies. In the illustrated embodiment, the first, second, third and fourth lengths are different, thus the first, second, third and fourth bands of frequencies are different. Again, however, the multi-band antenna **200** of FIG. **1** is achieving four different bands of frequencies in a space that might traditionally only achieve one or two different bands of frequencies.

The multi-band antenna **200** of FIG. **2** further includes a separate conductive segment **240**. The separate conductive segment **240** is additionally coupled to the feed portion **110**. In the illustrated embodiment, the separate conductive segment **240** operates in a single band of frequencies, for example a fifth band of frequencies. Moreover, unique to the present disclosure, in the embodiment of FIG. **1** the separate conductive segment **240** may be positioned proximate the conductive segment **120**, such that a capacitive coupling between the separate conductive segment **240** and the conductive segment **120** exists. Moreover, the capacitive coupling may be tailored, such that an effective length of the conductive segment **120** (as opposed to the actual length) increases without physically increasing the physical length of the conductive segment **120**. Accordingly, the actual first length of the conductive segment **120** can be shorter while still covering the lower frequency bands. Again, this technique can reduce the overall volume of the multi-band antenna **200**.

FIG. **3** illustrates alternative aspects of a representative embodiment of a multi-band antenna **300** in accordance with embodiments of the disclosure. Again, where used, like reference numerals indicate similar features. In addition to the features of FIG. **2**, the multi-band antenna **300** includes a parasitic arm **310**. The parasitic arm **310**, in accordance with the disclosure, may be used to lower the frequency and increase the bandwidth of the separate conductive segment **240**. Those skilled in the art, given the present disclosure, would understand the steps required to employ a parasitic arm, such as the parasitic arm **310**.

FIG. **4** illustrates an S-parameter plot **400** for a multi-band antenna in accordance with the present disclosure. The S-parameter plot **400** might, in one embodiment, be representative of the multi-band antenna **300** of FIG. **3**. In the illustrative embodiment, the first resonant portion **140** and second resonant portion **150** of the first conductive segment **120** might be found at positions, **410**, **420**, respectively, the third resonant portion **220** and fourth resonant portion **230** of the second conductive segment **210** might be found at about positions **430**, **440**, respectively, and the separate conductive segment **240** might be found at about position **450**. Obviously, this is but one configuration for a multi-band antenna. Accordingly, those skilled in the art appreciate that the geometries of the individual portions of the multi-band antenna may be modified, thereby changing the positions upon the plot **400**.

FIG. **5** shows a schematic diagram of electronic device **500**. Electronic device **500** may be a portable device such as a mobile telephone, a mobile telephone with media player capabilities, a handheld computer, a remote control, a game player, a global positioning system (GPS) device, a laptop computer, a tablet computer, an ultraportable computer, a combination of such devices, or any other suitable portable electronic device.

As shown in FIG. **5**, electronic device **500** may include storage and processing circuitry **510**. Storage and processing circuitry **510** may include one or more different types of storage such as hard disk drive storage, nonvolatile memory (e.g., flash memory or other electrically-programmable-read-only memory), volatile memory (e.g., static or dynamic random-access-memory), etc. Processing circuitry in storage and processing circuitry **510** may be used to control the operation of device **500**. Processing circuitry may be based on a processor such as a microprocessor and other suitable integrated circuits. With one suitable arrangement, storage and processing circuitry **510** may be used to run software on device **500**, such as internet browsing applications, voice-over-internet-protocol (VOIP) telephone call applications, email applications, media playback applications, operating system functions, etc. Storage and processing circuitry **510** may be used in implementing suitable communications protocols.

Communications protocols that may be implemented using storage and processing circuitry **510** include, without limitation, internet protocols, wireless local area network protocols (e.g., IEEE 802.11 protocols—sometimes referred to as WiFi®), protocols for other short-range wireless communications links such as the Bluetooth® protocol, protocols for handling 3 G communications services (e.g., using wide band code division multiple access techniques), 2G cellular telephone communications protocols, etc. Storage and processing circuitry **510** may implement protocols to communicate using 2G cellular telephone bands at 850 MHz, 900 MHz, 1800 MHz, and 1900 MHz (e.g., the main Global System for Mobile Communications or GSM cellular telephone bands) and may implement protocols for handling 3G and 4 G communications services.

Input-output device circuitry **520** may be used to allow data to be supplied to device **500** and to allow data to be provided from device **500** to external devices. Input-output devices **530** such as touch screens and other user input interfaces are examples of input-output circuitry **520**. Input-output devices **530** may also include user input-output devices such as buttons, joysticks, click wheels, scrolling wheels, touch pads, key pads, keyboards, microphones, cameras, etc. A user can control the operation of device **500** by supplying commands through such user input devices. Display and audio devices may be included in devices **530** such as liquid-crystal display (LCD) screens, light-emitting diodes (LEDs), organic light-emitting diodes (OLEDs), and other components that present visual information and status data. Display and audio components in input-output devices **530** may also include audio equipment such as speakers and other devices for creating sound. If desired, input-output devices **530** may contain audio-video interface equipment such as jacks and other connectors for external headphones and monitors.

Wireless communications circuitry **540** may include radio-frequency (RF) transceiver circuitry formed from one or more integrated circuits, power amplifier circuitry, low-noise input amplifiers, passive RF components, one or more antennas, and other circuitry for handling RF wireless signals. Wireless signals can also be sent using light (e.g., using infrared communications). Wireless communications circuitry **540** may include radio-frequency transceiver circuits for handling multiple radio-frequency communications bands. For example, circuitry **540** may include transceiver circuitry **542** that handles 2.4 GHz and 5 GHz bands for WiFi® (IEEE 802.11) communications and the 2.4 GHz Bluetooth® communications band. Circuitry **540** may also include cellular telephone transceiver circuitry **544** for handling wireless communications in cellular telephone bands such as the GSM bands at 850 MHz, 900 MHz, 1800 MHz, and 1900 MHz, as well as the UMTS and LTE bands (as examples). Wireless communications circuitry **540** can include circuitry for other short-range and long-range wireless links if desired. For example, wireless communications circuitry **540** may include global positioning system (GPS) receiver equipment, wireless circuitry for receiving radio and television signals, paging circuits, etc. In WiFi® and Bluetooth® links and other short-range wireless links, wireless signals are typically used to convey data over tens or hundreds of feet. In cellular telephone links and other long-range links, wireless signals are typically used to convey data over thousands of feet or miles.

Wireless communications circuitry **540** may include antennas **546**. Device **500** may be provided with any suitable number of antennas. There may be, for example, one antenna, two antennas, three antennas, or more than three antennas, in device **500**. At least one of the antennas **546** in the device **500**, in one embodiment, is similar to the antennas illustrated and described with regard to FIGS. **2-3** above. In accordance with that discussed above, the antennas may handle communications over multiple communications bands. If desired, a dual band antenna may be used to cover two bands (e.g., 2.4 GHz and 5 GHz). Different types of antennas may be used for different bands and combinations of bands. For example, it may be desirable to form a multi-band antenna for forming a local wireless link antenna, a multi-band antenna for handling cellular telephone communications bands, and a single band antenna for forming a global positioning system antenna (as examples).

Paths **550**, such as transmission line paths, may be used to convey radio-frequency signals between transceivers **542** and **544**, and antennas **546**. Radio-frequency transceivers such as radio-frequency transceivers **542** and **544** may be implemented using one or more integrated circuits and associated components (e.g., power amplifiers, switching circuits, matching network components such as discrete inductors, capacitors, and resistors, and integrated circuit filter networks, etc.). These devices may be mounted on any suitable mounting structures. With one suitable arrangement, transceiver integrated circuits may be mounted on a printed circuit board. Paths **550** may be used to interconnect the transceiver integrated circuits and other components on the printed circuit board with antenna structures in device **500**. Paths **550** may include any suitable conductive pathways over which radio-frequency signals may be conveyed including transmission line path structures such as coaxial cables, microstrip transmission lines, etc.

The device **500** of FIG. **5** further includes a chassis **560**. The chassis **500** may be used for mounting/supporting electronic components such as a battery, printed circuit boards containing integrated circuits and other electrical devices, etc. For example, in one embodiment, the chassis **560** positions and supports the storage and processing circuitry **510**, and the input-output circuitry **520**, including the input-output devices **530** and the wireless communications circuitry **540** (e.g., including the WIFI and Bluetooth transceiver circuitry **542**, the cellular telephone circuitry **544**, and the antennas **546**.

The chassis **560**, in one embodiment, is a metal chassis. For example, the chassis **560** may be made of various different metals, such as aluminum. Chassis **560** may be machined or cast out of a single piece of material, such as aluminum. Other methods, however, may additionally be used to form the chassis **560**.

Those skilled in the art to which this application relates will appreciate that other and further additions, deletions, substitutions and modifications may be made to the described embodiments.

What is claimed is:

1. A multi-band antenna, comprising:
- a first resonant portion having a first length defined by an outer perimeter of a conductive segment and operable to effect an antenna for communication in a first band of frequencies; and
- a second resonant portion having a second length defined by an inner perimeter of the conductive segment and operable to resonate capacitively for communication in a second different band of frequencies.

2. The multi-band antenna of claim **1**, wherein the first resonant portion and the second resonant portion are substantially planar portions.

3. The multi-band antenna of claim **1**, wherein the conductive segment is formed as a partial loop.

4. The multi-band antenna of claim **3**, wherein the conductive segment folds back upon itself to form the partial loop.

5. The multi-band antenna of claim **4**, wherein the conductive segment includes a first section, a second section coupled to and shorter than the first section, and a third section coupled to the second section and doubling back on the first section.

6. The multi-band antenna of claim **5**, wherein the first section and second section are substantially perpendicular to one another, and the first section and third section are substantially parallel to one another.

7. The multi-band antenna of claim **1**, wherein one of the first length or the second length may be modified without modifying the other of the second length or the first length.

8. The multi-band antenna of claim **7**, wherein a thickness of at least a portion of the conductive segment is adjusted to modify the one of the first length or the second length without modifying the other of the second length or the first length.

9. The multi-band antenna of claim **1**, wherein the conductive segment is a first conductive segment, and further including a second conductive segment, wherein the second conductive segment includes:
- a third resonant portion having a third length defined by an outer perimeter of the second conductive segment and operable to effect an antenna for communication in a third band of frequencies; and
- a fourth resonant portion having a fourth length defined by an inner perimeter of the second conductive segment and operable to resonate capacitively for communication in a fourth different band of frequencies.

10. The multi-band antenna of claim **1**, further including a separate conductive segment, the separate conductive segment positioned proximate the conductive segment, such that a capacitive coupling between the separate conductive segment and the conductive segment provides an effective length of the conductive segment greater than an actual length of the conductive segment.

11. An electronic device, comprising:
- storage and processing circuitry;
- input-output devices associated with the storage and processing circuitry; and

wireless communications circuitry including a multi-band antenna, the multi-band antenna including;

a first resonant portion having a first length defined by an outer perimeter of a conductive segment and operable to effect an antenna for communication in a first band of frequencies; and

a second resonant portion having a second length defined by an inner perimeter of the conductive segment and operable to resonate capacitively for communication in a second different band of frequencies.

12. The electronic device of claim **11**, wherein the first resonant portion and the second resonant portion are substantially planar portions.

13. The electronic device of claim **11**, wherein the conductive segment is formed as a partial loop.

14. The electronic device of claim **13**, wherein the conductive segment folds back upon itself to form the partial loop.

15. The electronic device of claim **14**, wherein the conductive segment includes a first section, a second section coupled to and shorter than the first section, and a third section coupled to the second section and doubling back on the first section.

16. The electronic device of claim **15**, wherein the first section and second section are substantially perpendicular to one another, and the first section and third section are substantially parallel to one another.

17. The electronic device of claim **11**, wherein one of the first length or the second length may be modified without modifying the other of the second length or the first length.

18. The electronic device of claim **17**, wherein a thickness of at least a portion of the conductive segment is adjusted to modify the one of the first length or the second length without modifying the other of the second length or the first length.

19. The electronic device of claim **11**, wherein the conductive segment is a first conductive segment, and further wherein the multi-band antenna includes a second conductive segment, wherein the second conductive segment includes:

a third resonant portion having a third length defined by an outer perimeter of the second conductive segment and operable to effect an antenna for communication in a third band of frequencies; and

a fourth resonant portion having a fourth length defined by an inner perimeter of the second conductive segment and operable to resonate capacitively for communication in a fourth different band of frequencies.

20. The electronic device of claim **11**, wherein the multiband antenna further includes a separate conductive segment, the separate conductive segment positioned proximate the conductive segment, such that a capacitive coupling between the separate conductive segment and the conductive segment provides an effective length of the conductive segment greater than an actual length of the conductive segment.

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